(h) mass of solution = 170.2 g sugar + 500.0 mL $H_2O\left(\frac{1.00\text{ g }H_2O}{1\text{ mL }H_2O}\right)$ = 670.2 g

density = $\frac{670.2\text{ g}}{531\text{ mL}}$ = 1.26 g/mL

500.0 mL × $\frac{1.00\text{ g }H_2O}{1\text{ mL}}$ × $\frac{203.9\text{ g sugar}}{100.0\text{ g }H_2O}$ = 1.02×10^3 g sugar can be dissolved.

The solution is thus unsaturated: $170.2 < 1.02 \times 10^3$

(i) 68 mL H_2O = 68 g H_2O

At 90°C: 68 g H_2O × $\frac{415.7\text{ g sugar}}{100\text{ g }H_2O}$ = 283 g sugar can be dissolved. Since 283 > 237, yes.

At 20°C: 68 g H_2O × $\frac{203.9\text{ g sugar}}{100\text{ g }H_2O}$ = 139 g sugar can be dissolved. Since 237 g of sugar were in solution, 98 g will crystalize out (237 − 139 = 98).

(j) no color is absorbed; between 400 nm (ultraviolet) and 700 nm (infrared)

PROBLEMS Chap 1

1. (a) mixture (b) element (c) mixture (d) compound

3. (a) solution (b) solution (c) heterogeneous mixture

5. (a) chromatography (b) filtration

7. (a) Ti (b) P (c) K (d) Mg

9. (a) mercury (b) silicon (c) sodium (d) iodine

11. (a) balance (b) thermometer (c) graduated cylinder

13. $t_{°F}$ = 1.8(52°) + 32° = 126°F; t_K = 52 + 273.15 = 325 K

15. $t_{°C}$ = 4.22 − 273.15 = −268.93°C; $t_{°F}$ = 1.8(−268.93°) + 32° = −452.07°F

17. (a) 6 (b) 4 (c) 4 (d) 3

(e) questionable; 1, 2 or 3

19. (a) 7.49 g (b) 298.69 cm (c) 1×10^1 lb (d) 12.0 oz

21. (a) 4.6332×10^3 mg (b) 4.73×10^{-4} L (c) 1.270000×10^5 cm^3

23. (b), (c)

25. 10,000: ambiguous 1.71×10^5 ft^2: 3 \$22.00: exact 20%: ambiguous

27. (a) 80.0 (b) 0.7615 (c) 14.712 (d) 0.03

29. $\frac{4\pi(4.30\text{ cm})^3}{3} = 333\text{ cm}^3$; $\frac{4\pi(4.33\text{ cm})^3}{3} = 340\text{ cm}^3$; 7 cm^3

31. (a) 303 m = 0.303 km < 303×10^3 km (b) 500 g = 0.500 kg

(c) $1.50\text{ cm}^3 = 1.50 \times 10^{21}\text{ nm}^3 > 1.50 \times 10^3\text{ nm}^3$

33. (a) $22.3\text{ mL} \times \frac{1\text{ L}}{10^3\text{ mL}} = 2.23 \times 10^{-2}\text{ L}$ (b) $22.3\text{ cm}^3 \times \frac{1\text{ in}^3}{(2.54\text{ cm})^3} = 1.36\text{ in}^3$

(c) $22.3\text{ mL} \times \frac{1\text{ L}}{10^3\text{ mL}} \times \frac{1.057\text{ qt}}{1\text{ L}} = 0.0236\text{ qt}$

35. (a) $19.2\text{ hands} \times \frac{\frac{1}{3}\text{ ft}}{1\text{ hand}} = 6.40\text{ ft}$

(b) $17.8\text{ hands} \times \frac{\frac{1}{3}\text{ ft}}{1\text{ hand}} \times \frac{12\text{ in}}{1\text{ ft}} \times \frac{1\text{ m}}{39.37\text{ in}} = 1.81\text{ m}$

(c) $20.5\text{ hands} \times \frac{\frac{1}{3}\text{ ft}}{1\text{ hand}} + 3.0\text{ ft} = 9.8\text{ ft}$

37. $2.0\text{ acre} \times \frac{4.356 \times 10^4\text{ ft}^2}{1\text{ acre}} \times \frac{(12)^2\text{ in}^2}{1\text{ ft}^2} \times \frac{1\text{ m}^2}{(39.37)^2\text{ in}^2} \times \frac{1\text{ hectare}}{10^4\text{ m}^2} = 0.81\text{ hectare}$

39. $1\text{ pt} \times \frac{1\text{ qt}}{2\text{ pt}} \times \frac{1\text{ L}}{1.057\text{ qt}} = 0.4730\text{ L donated.}$ $\frac{0.4730\text{ L}}{6.0\text{ L}} \times 100 = 7.9\%$

41. (a) $3.0\text{ qt plasma} \times \frac{1\text{ L}}{1.057\text{ qt}} \times \frac{1000\text{ mL}}{1\text{ L}} \times \frac{0.080\text{ mL alcohol}}{100\text{ mL plasma}} = 2.3\text{ mL}$

(b) $3.0\text{ qt plasma} \times \frac{1\text{ L}}{1.057\text{ qt}} \times \frac{1000\text{ mL}}{1\text{ L}} \times \frac{0.10\text{ mL alcohol}}{100\text{ mL plasma}} = 2.8\text{ mL}$

(c) 2.8 mL − 2.3 mL = 0.5 mL

43. $\frac{235\ \text{kJ}}{250\ \text{mL}} \times \frac{10^3\ \text{J}}{1\ \text{kJ}} \times \frac{1\ \text{cal}}{4.18\ \text{J}} \times \frac{1\ \text{kcal}}{10^3\ \text{cal}} \times \frac{1000\ \text{mL}}{1.057\ \text{qt}} \times \frac{1\ \text{qt}}{4\ \text{cups}} = 53.2\ \text{kcal/cup}$

45. $\frac{252\ \text{g}}{0.750 \times 225\ \text{mL}} = 1.49\ \text{g/mL}$

47. $V_{\text{methanol}} = 43.7\ \text{g} \times \frac{1\ \text{mL}}{0.791\ \text{g}} = 55.2\ \text{mL}$, $V_{\text{slug}} = 59.7\ \text{mL} - 55.2\ \text{mL} = 4.5\ \text{mL}$

Therefore, $d_{\text{slug}} = \frac{25.17\ \text{g}}{4.5\ \text{mL}} = 5.6\ \text{g/mL}$

49. $(8.0 \times 7.0 \times 0.75)\ \text{ft}^3 \times \frac{(12)^3\ \text{in}^3}{1\ \text{ft}^3} \times \frac{(2.54)^3\ \text{cm}^3}{1\ \text{in}^3} \times \frac{1.00\ \text{g}}{1\ \text{cm}^3} \times \frac{1\ \text{kg}}{1000\ \text{g}} = 1.2 \times 10^3\ \text{kg}$

51. $5.00\ \text{L vinegar} \times \frac{1000\ \text{mL}}{1\ \text{L}} \times \frac{1.01\ \text{g vinegar}}{1\ \text{mL}} \times \frac{5.00\ \text{g acetic acid}}{100\ \text{g vinegar}} = 252\ \text{g acetic acid}$

53. $35.0\ \text{g } H_2O \times \frac{1.85\ \text{g } Ba(OH)_2}{100\ \text{g } H_2O} = 0.648\ \text{g } Ba(OH)_2 = 648\ \text{mg } Ba(OH)_2$ can be dissolved in 35.0 g H_2O.

Since 256 mg < 648 mg, the solution is unsaturated.

55. (a) $44.5\ \text{g } H_2O \times \frac{37.0\ \text{g KCl}}{100\ \text{g } H_2O} = 16.5\ \text{g KCl}$ (b) $39.6\ \text{g KCl} \times \frac{100\ \text{g } H_2O}{48.3\ \text{g KCl}} = 82.0\ \text{g } H_2O$

(c) At 30°C: $75.0\ \text{g } H_2O \times \frac{37.0\ \text{g KCl}}{100\ \text{g } H_2O} = 27.8\ \text{g KCl}$ will dissolve. Not all the KCl will dissolve.

40.0 – 27.8 = 12.2 g KCl will remain undissolved.

At 70°C: $75.0\ \text{g } H_2O \times \frac{48.3\ \text{g KCl}}{100\ \text{g } H_2O} = 36.2\ \text{g KCl}$ will dissolve.

Thus, 40.0 – 36.2 = 3.8 g will remain undissolved.

57. 57.0 g – 25.0 g = 32.0 g of $Pb(NO_3)_2$ dissolves in 64.0 g H_2O at 10°C. Solubility is

$$\frac{32.0\ \text{g } Pb(NO_3)_2}{64.0\ \text{g } H_2O} = \frac{1.00\ \text{g } Pb(NO_3)_2}{2.00\ \text{g } H_2O} = \frac{50.0\ \text{g } Pb(NO_3)_2}{100.0\ \text{g } H_2O}$$

59. (a) physical (b) physical (c) physical (d) chemical

61. $1\ \text{g Pb} \times \frac{1\ \text{cm}^3}{11.34\ \text{g}} = 0.08818\ \text{cm}^3$, $1\ \text{g } O_2 \times \frac{1\ \text{cm}^3}{1.31 \times 10^{-3}\ \text{g}} = 763\ \text{cm}^3$

Pb is a solid; O_2 is a gas.

63. $108 \text{ carats} \times \dfrac{0.200 \text{ g}}{1 \text{ carat}} \times \dfrac{1 \text{ lb}}{454 \text{ g}} = 0.0476 \text{ lb}$

$$0.0476 \text{ lb} \times \frac{1 \text{ cm}^3}{3.51 \text{ g}} \times \frac{454 \text{ g}}{1 \text{ lb}} \times \frac{1 \text{ in}^3}{(2.54)^3 \text{ cm}^3} = 0.376 \text{ in}^3$$

65. $153.2 \text{ g} \times \dfrac{1 \text{ cm}^3}{4.55 \text{ g}} = 33.7 \text{ cm}^3 = V; \quad 33.7 = \pi r^2(7.75); \quad r = 1.18 \text{ cm}; \quad d = 2.35 \text{ cm}$

67. (a) Chemical properties show the behavior of the species in a reaction; physical properties are intrinsic qualities.

(b) Distillation vaporizes the liquid; filtration removes the solid.

(c) The solute is a component of the solution.

69. The bottom layer is Hg; the middle layer is Pb; the top layer is ethyl alcohol.

71. (a) ≈ 115 g; supersaturated (b) ≈ 30 g; unsaturated

(c) Dissolve 30 g of compound in 100 g H_2O.

73. $2\, t_{°C} = 1.8\, t_{°C} + 32°; \qquad 0.2\, t_{°C} = 32°; \qquad t_{°C} = 160°, \quad t_{°F} = 320°$

74. $31.5 \text{ gal} \times \dfrac{4 \text{ qt}}{1 \text{ gal}} \times \dfrac{1 \text{ L}}{1.057 \text{ qt}} \times \dfrac{10^{-3} \text{ m}^3}{1 \text{ L}} \times \dfrac{1 \text{ km}^3}{10^9 \text{ m}^3} = \left(1.0 \times 10^{-10} \text{ km}\right) (\text{area}).$

Solving, area = 1.2 km^2.

75. $V = 12.0 \text{ g} \times \dfrac{1 \text{ cm}^3}{2.70 \text{ g}} = \pi(0.254 \text{ cm})^2 \ell; \qquad \ell = 21.9 \text{ cm}$

76. $\dfrac{8.50 \times 10^3 \text{ L}}{1 \text{ d}} \times \dfrac{1 \text{ m}^3}{10^3 \text{ L}} \times \dfrac{7.0 \times 10^{-6} \text{ g Pb}}{1 \text{ m}^3} \times 0.75 \times 0.50 \times \dfrac{365 \text{ d}}{1 \text{ yr}} = 8.1 \times 10^{-3} \text{ g Pb}$

DEMONSTRATIONS

1. Law of constant composition: GILB A 12
2. Law of conservation of mass: GILB A 16
3. Simulation of Rutherford's experiment: GILB L 7
4. Isotope effects (H_2O, D_2O): GILB M 18
5. Reaction of hydrogen with chlorine: GILB H 38
6. Conductivity of water solutions: SHAK 3 140
7. Breath alcohol detection: J. Chem. Educ. *67* 263 (1990); *71* 158 (1994)

SUMMARY PROBLEM

(a) ionic; yes (b) NaCl (c) molecular; ICl_3; no

(d) atomic numbers: Na-11, Cl-17 (e) $^{21}_{11}Na$

(f) Na: Group 1, period 3, metal, Cl: Group 17, period 3, nonmetal

(g) 20 (h) $AlCl_3$: aluminum chloride

(i) ClO_2: chlorine dioxide ClO_2^-: chlorite ion $HClO_2(aq)$: chlorous acid
$NaClO_2$: sodium chlorite

PROBLEMS Chap 2

1. p. 27

3. (a) Conservation of mass (b) Constant composition
(c) neither

5. J. J. Thompson; see p. 28 7. $^{80}_{34}Se$

9. no. of neutrons: $^{63}_{29}Cu$, $^{65}_{29}Cu$

11. (a) 92 (b) 143 (c) 92 (d) 143n, 92p^+, 90e^-

13. (a) 14p^+, 16n, 14e^-; R = Si (b) 39p^+, 50n, 39e^-; T = Y
(c) 55p^+, 78n, 55e^-; X = Cs

15. (a) Ca-41, K-41, Ar-41 are isobars; Ca-40, Ca-41 are isotopes

(b) atomic number = number of protons = 20 (c) same mass number

17. (a) K (b) Cd (c) Al (d) Sb

(e) P

19. (a) main-group metal (b) transition metal (c) main-group metal (d) metalloid

(e) nonmetal

21. (a) 6 (b) 4 (c) 0

23. (a) 13 (b) 2 (c) 17, 18

25. (a) C_2H_7N (b) C_3H_8O

27. (a) $14p^+, 14e^-$ (b) $21p^+, 22e^-$ (c) $35p^+, 34e^-$ (d) $70p^+, 70e^-$

29.

$^{19}_{9}F$	0	9	10	9
$^{31}_{15}P$	0	15	16	15
$^{57}_{27}Co^{3+}$	+3	27	30	24
$^{32}_{16}S^{2-}$	−2	16	16	18

31. (a) electrolyte (b) nonelectrolyte (c) nonelectrolyte (d) electrolyte

33. (a) CH_4 (b) Cl_4 (c) H_2O_2 (d) NO

(e) SiO_2

35. (a) iodine trichloride (b) dinitrogen pentaoxide (c) phosphine (d) carbon tetrabromide

(e) sulfur trioxide

37. KCl, K_2S, $CaCl_2$, CaS

39. (a) $Fe_2(CO_3)_3$ (b) NaN_3 (c) $CaSO_4$ (d) Cu_2S

(e) PbO_2

41. (a) potassium dichromate (b) copper(II) phosphate

(c) barium acetate (d) aluminum nitride (e) cobalt(II) nitrate

43. (a) hydrochloric acid (b) chloric acid (c) iron(III) sulfite (d) barium nitrite

(e) sodium hypochlorite

45. HNO_2, nickel(II) iodate, Au_2S_3, sulfurous acid, NF_3

47. (a) $Mn(NO_2)_3$; manganese(III) nitrite (b) BF_3; boron trifluoride

(c) $Ca(HCO_3)_2$; calcium hydrogen carbonate

49. (a) H_2 : $2p^+$, $2e^-$, $0n$ H^-: $1p^+$, $2e^-$, $0n$ H^+: $1p^+$, $0e^-$, $0n$

(b) magnesium hydride, MgH_2 (c) acid

51. (a) only if cation and anion have the same charge (e.g., +1, −1)

(b) no molecules in $SrBr_2$ (c) almost never, except for ${}^1_1H$ (d) any anion

53. (b), (d), (e)

55. 8 □○ molecules; 3 □□ molecules left

57. A square with four circles around it (several of them in a flask with a defined volume)

59. (a) 118 (b) 120 (c) 117 (d) 120

(e) 119

61. first experiment: $\%\,O = \frac{3.87}{52.30} \times 100 = 7.40$; $\%\,Hg = 92.60$

second experiment: $\%\,Hg = \frac{15.68}{16.93} \times 100 = 92.62$; $\%\,O = 7.38$

63. A: mass C/mass H = 11.9 B: mass C/mass H = 2.99

(a) ratio = 2.77 (b) ratio = 4.67 (c) ratio = 5.96

(d) follows: A:C:B = 12:6:3

64. (a) ethane: 18.0 g C/4.53 g H = 3.97 g C/g H ethylene: 43.20 g C/7.25 g H = 5.96 g C/g H

5.96/3.97 = 1.50 = 3/2 (b) CH_2 and CH_3; C_2H_4 and C_2H_6

65. mass = $13\,(1.6726 \times 10^{-4}\,g) + 13\,(9.1094 \times 10^{-28}\,g) + 14\,(1.6749 \times 10^{-24}\,g) = 4.5204 \times 10^{-23}\,g$

$V = \frac{4}{3}\pi\,(1.43 \times 10^{-8}\,cm)^3 = 1.22 \times 10^{-23}\,cm^3$; $d = 4.5204\,g/1.22\,cm^3 = 3.71\,g/cm^3$

Empty space between Al atoms.

66. $1.4965 \times 10^{-23}\,g - 2\,(9.1094 \times 10^{-28}\,g) = 1.4963 \times 10^{-23}\,g$

67. (a) $200 \times 500 \times 2.5 \times 10^{19} = 2.5 \times 10^{24}$ molecules

(b) $\dfrac{2.5 \times 10^{24}}{1.1 \times 10^{44}} = 2.3 \times 10^{-20}$

(c) $(2.3 \times 10^{-20}) \times 500 \times (2.5 \times 10^{19}) \approx 2.9 \times 10^{2}$